Testing the Integration of U.S.–Canadian Meat and Livestock Markets

Thomas Vollrath[1] and Charles Hallahan[2]

[1]*Economist, Economic Research Service, USDA, 1800 M. Stree N.W., Washington, D.C. 20036 (phone: (202) 694-5241; fax (202) 694-5793; e-mail: thomasv@ers.usda.gov).*
[2]*Mathematician, Economic Research Service, USDA. 1800 M. Street N.W., Washington, D.C. 20036 (phone: (202) 694-5051; fax (202) 694-5718; e-mail: hallahan@ers.usda.gov).*

Price transmission is a critically important issue that affects market enlargement and the unification of Canadian–U.S. agriculture. This study adopts alternative frameworks to examine the nature of cross-border integration in selected meat and livestock markets. The aim is to determine the extent to which selected meat and livestock markets transmit price signals across the international border using time-series data through 2001. Typically, price-based studies examining market integration across countries ignore important spatial and temporal factors affecting commodity price relationships such as adjustments lags, changes in the value of national currencies, and policy-induced trade barriers. Here, we account for such factors in our two model specifications. The first model is based upon the law-of-one price (LOP) framework and focuses on spatial efficiency. The second analytical framework is the vector autoregressive (VAR) model that highlights the dynamic notion of market connectedness. The LOP analysis permits us to formally test the existence of perfect market integration and complete market segmentation. The VAR analysis enables us to gauge price-shock transference. Empirical evidence is generated confirming that the two national markets for whole chicken are segmented, a not unsurprising finding given that poultry is a supply managed sector in Canada. The Canadian–U.S. hog- and pork-product markets were found to be more integrated than the Canadian–U.S. steer- and beef-product markets. Evidence is also provided showing that the Canadian–U.S. exchange rate inhibits cross-border integration in these commodity markets.

La transmission des prix est un sujet extrêmement important qui gêne l'expansion des marchés et l'unification de l'agriculture du Canada et des États-Unis. Dans la présente étude, nous avons utilisé divers cadres d'analyse pour examiner la nature de l'intégration transfrontalière de marchés sélectionnés de la viande et des bestiaux. L'objectif consistait à déterminer l'étendue avec laquelle des marchés sélectionnés de la viande et des bestiaux transmettent des signaux de prix au-delà des frontières en utilisant des données de séries chronologiques jusqu'en 2001. Généralement, les études de prix qui examinent l'intégration des marchés entre les pays font abstraction de facteurs spatiaux et temporels importants touchant le rapport des prix des produits de base tels que le décalage dans les rajustements, la variation du cours des devises nationales et les obstacles au commerce induits par les politiques. Dans le présent article, nous avons tenu compte de ces facteurs dans les spécifications de deux modèles. Le premier est modèle fondé sur la loi du prix unique qui met l'accent sur l'efficacité spatiale. Le deuxième est un modèle d'autorégression vectorielle (VAR) qui met en évidence la notion dynamique de la connexité des marchés. Le modèle fondé sur la loi du prix unique nous a permis de vérifier l'existence de l'intégration parfaite et de la segmentation totale des marchés. Le modèle d'autorégression vectorielle nous a permis d'évaluer le transfert d'un choc de prix. L'évidence empirique a confirmé que les deux marchés nationaux du poulet entier étaient segmentés, un résultat qui n'est pas sans surprise compte tenu que l'élevage du poulet au Canada est un secteur soumis à la gestion de l'offre.

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Nous avons trouvé que les marchés canado-américains des porcs et de la viande porcine étaient plus intégrés que les marchés canado-américains des bovins et de la viande bovine. L'évidence empirique a également montré que le taux de change entravait l'intégration transfrontalière de ces marchés de produits de base.

INTRODUCTION

Market integration is an important issue because it affects economic growth, induces structural change, alters the location of economic activity, and bears upon the viability of small and large agricultural enterprises. It is an issue of particular concern to policymakers responsible for maximizing economic opportunities and minimizing conflict for the body politic (Farm Foundation 2004). Consumers benefit from integration because they can purchase goods at the lowest possible prices. The attempt to enlarge the agricultural market in North America has, however, generated considerable controversy, particularly among various farm communities.[1]

In this study, we focus on specific meat and livestock product markets in the United States and Canada and examine the extent to which these markets exhibit price integration based upon the transmission of shocks across national boundaries. The empirical analysis focuses on slaughter steers, hogs, whole chicken, two cuts of beef (chuck and beef loin), and two pork products (ham and spare ribs)—goods produced in and traded by both countries for which lengthy price-series data are available.[2] An ancillary objective of this study is to determine the impact of the Canadian–U.S. Free Trade Agreement (CUSTA) implemented in 1989 and its extension the 1994 North American Free Trade Agreement (NAFTA).

AN OVERVIEW OF THE U.S. AND CANADIAN MEAT AND LIVESTOCK SECTORS

Two-way trade characterizes Canadian–U.S. trade in meat and livestock. Canadian exports of cattle, swine, beef, and pork are greater than trade in the other direction; but U.S. exports have experienced substantial growth during the past decade. The United States has maintained a positive trade balance in live birds and poultry meat; however, Canada's exports to the United States have been rising in these areas in recent years.

The mindset of commodity experts and among most U.S. and Canadian livestock producers and meat processors is that the United States and Canada is a single market. Haley (2004) contends that "it is more accurate to talk about a North American pork industry" than a U.S. or Canadian industry. Young and Marsh (1998) assert that "integration of U.S. and Canadian live cattle and beef markets is well advanced, and it is perhaps the most integrated market of the major agricultural commodities." The fact that Canadian and U.S. wholesale price series for most meats and live animals move together and are similar in magnitude points to integrated, cross-border markets throughout much of the sector.

Poultry is considered to be an exception to the notion of a single market in the meat and livestock sector as poultry is a supply managed subsector in Canada. Agricultural economists believe that the Canadian–U.S. beef and cattle industry, like the pork and swine industry, is more highly integrated than the Canadian–U.S. poultry sector; that is,

until the discovery of cows with bovine spongiform encephalopathy (BSE) in the United States and Canada in late 2003 and early 2004. (All empirical analyses in this study were done prior to the discovery of BSE in North America.)

Poultry Meat

Historically, the price of poultry meat has been considerably higher in Canada than in the United States. At the outset of CUSTA/NAFTA, the U.S. dollar price of whole chicken in Canada was double that of the United States, but declined to a 20% premium by 2002 due, in part, to the steady depreciation of the Canadian dollar. Production and import quotas continue, however, to shield the Canadian industry, preventing it from becoming more efficient. The U.S. industry, by contrast, has been and continues to be internationally competitive.

CUSTA/NAFTA rendered the U.S. industry more open, but did not change the essential character of the Canadian industry. Under the agreement, the United States was induced to eliminate tariffs on Canadian poultry meat, which had ranged from 2 to 10.6 cents/kg. U.S. post-CUSTA/NAFTA tariff reductions for poultry, as with other meats, were accelerated to completion (USDA 2002).

Canada, by contrast, was not willing to fundamentally alter its domestic poultry policy within CUSTA/NAFTA.[3] It refused to abandon its production-quota system. Canada continues to maintain tariff-rate quotas on imports because without such restrictions its domestic poultry program would not be effective. Canada did, however, augment import quotas for U.S. poultry meat under the agreement, enabling U.S. exporters to gain preferential access to the Canadian poultry market.

In CUSTA/NAFTA, the United States and Canada agreed to work toward the elimination of technical barriers to poultry trade by setting up working groups to achieve inspection equivalencies. While Canada was unwilling to relinquish its domestic poultry program in the CUSTA/NAFTA, progress has been achieved in harmonizing poultry regulations (de Gorter and de Valk 1997).

Pork and Swine

Neither United States nor Canada levied tariffs on swine, except for temporary tariffs levied the Canadian hogs in late 2004.[4] There have, however, been nontariff barriers inhibiting pork trade. The United States maintained CVDs on Canadian live swine from April 3, 1985 through March 31, 1997. Moreover, Canada restricted, until very recently, U.S. swine imports for sanitary reasons. On December 3, 1998, Canada amended its Health of Animal Regulation to permit the importation of U.S. slaughter pigs from certain States recognizing U.S. disease testing and quarantine requirements under the U.S. Psedorabies Eradication Program. (USDA 2002).

The U.S. and Canadian trade restrictions on each other's pork products were quickly phased out under CUSTA/NAFTA (USDA 2002). However, the duties on pork that did exist prior to the agreement were so low as to be considered a nuisance rather than an important barrier to trade (Kerr and Cullen 1985). Moreover, the existence of pre-CUSTA/NAFTA quotas, designed to protect against import surges, were imposed so seldom that they were also considered more of an annoyance than a real trade barrier (Kerr et al 1986).

Beef and Cattle

Prior to CUSTA/NAFTA, U.S. and Canadian tariffs on beef and cattle had been quite low with most cattle being charged 2.2 cents/kg. Under the free trade agreement, both countries completely phased out tariffs on each other's exports under accelerated reduction schedules until they were completely eliminated by January 1, 1993 (USDA 2002). Moreover, the agreement also exempted both countries from each other's domestic meat import laws, laws which continue to restrict imports from non-NAFTA suppliers.

In addition to the removal of tariffs and domestic restrictions on meat imports, other developments may have also affected Canadian–U.S. trade and market integration in the cattle and beef industry. In the fall of 1998, the Restricted Feeder Cattle Program eliminated the testing of U.S. feeder cattle produced in most states and provinces for brucellosis, tuberculosis, and other diseases —regulations that Brester and Smith (2000) contend curtailed U.S. exports to Canada. Moreover, recent cross-border investments have advanced cross-border market unification throughout the industry. Two major U.S. packers—IBP and Cargill/Excel—built large processing facilities in southern Alberta, increasing the capacity of Canada to export beef products south of the border.

As a result of the aforementioned policy and structural shifts, economists and industry experts contend that both countries were better able to exploit their natural geographic advantages and reap economic gains from increased specialization and trade in beef and cattle. U.S. producers increased exports to eastern Canada; and Canadian producers increased exports to the western United States. Commodity analysts at USDA's Economic Research Service (ERS) have estimated that the greater market access secured by CUSTA/NAFTA was responsible for quadrupling Canadian exports of beef to the United States and for doubling the amount of U.S. beef exported to Canada (USDA 2002).

The growth in cross-border trade and investment suggests that Canadian beef and cattle markets have become more integrated with markets in the United States. Nontariff barriers continue, however, to disrupt the joint Canadian–U.S. market from time-to-time. For example, the United States imposed tariffs on Canadian imports of slaughter cattle in response to (1) a petition filed by Ranchers-Cattlemen Action Legal Fund, whose members are from the Northern Great Plains and Rockies region, and (2) a ruling by the U.S. International Trade Commission (USITC) that domestic producers may have been materially injured by Canadian dumping in June 1999 (Brester et al 2002). These tariffs were rescinded by the USITC in its final ruling in November 1999.

Persistent nontariff barriers affecting beef are country-of-origin labeling and the absence of national grade equivalencies. In eastern Canada, U.S. beef is not sold side by side with Canadian beef in retail outlets and in Ontario U.S. beef is classified as "ungraded." As a result, sales of U.S. beef in Canadian are constrained. Sales of Canadian beef in the United States are also constrained. Boxed choice Canadian beef marketed in the United States cannot receive the USDA stamp of approval and must be sold at a "no-roll" discount. Moreover, the United States requires that beef imports be labeled by country-of-origin when entering the country (Brester and Smith 2000). Commodity analysts believe that such nontariff barriers drive a wedge between the two national markets in this industry (Hayes and Kerr 1997).

To determine the nature and the extent of the Canadian–U.S. market integration in specific meat and livestock commodities/products, we now turn to time-series econometric analyses.

THE LAW-OF-ONE-PRICE AND MARKET CONNECTEDNESS

Economists have used different definitions and diagnostic tools to analyze market integration through time and across space. According to Dornbusch (1987), the notion of a spatially integrated market is consistent with the law-of-one-price (LOP), when abstracting from transportation and real-world frictions inhibiting trade. This law states that prices will either equalize (i.e., the absolute LOP) or move in tandem across freely trading areas (i.e., the relative LOP). Indeed, many economists have used the LOP framework to test hypotheses about market integration. See, for example, Richardson (1978), Crouhy-Veyrac et al (1982), Ravillion (1986), Carter and Hamilton (1989), Goodwin and Schroeder (1991), and Sexton et al (1991).

McNew (1996) provides a new perspective of what constitutes an integrated market. He posits that market integration be identified with "market connectedness," where connectedness relates to the transmission of price shocks in both spatial and temporal terms. This view of market integration is enriching for it explicitly focuses on the price adjustment process.

In a survey article, Fackler and Goodwin (2000) clarify some issues by pointing out that market integration often refers to a measure of degree rather than to a specific relationship as is the case with strict adherence to the LOP. At one extreme are completely segmented spatial markets and at the other are perfectly integrated spatial markets. Fackler and Goodwin also point out that market integration may not be symmetric; that is, region A can be more integrated with region B than vice versa. Finally, they underscore the desirability of incorporating dynamic elements capable of allowing price adjustments to take place through time in analyses of market integration. Such an expansive view of market integration points to limitations underlying analyses based solely upon contemporaneous prices.

In this study, we adopt a multifaceted approach. The theoretical underpinnings of the models that we estimated are based upon what underlie and depict integrated markets, namely, the LOP and the notion of market connectedness. In specifying our empirical models, we control for factors that are likely to affect spatial prices, such as delivery lags, transaction costs, seasonal cycles, and government policies. This enables us to accurately gauge the efficiency of the arbitrage mechanism and the transmission of price shocks.

"Streamlined" LOP models are estimated to ascertain whether Canadian and U.S. commodity prices, expressed in a common-currency terms, tend toward uniformity. "Detailed" LOP models are used to quantify foreign-price and exchange-rate transmission elasticities and to test joint hypotheses of the equality of parameter estimates. The "market-connectedness" approach is adopted to focus on the dynamics of price-shock transference.

Spatial Integration

In a competitive and efficient market, area prices equilibrate and/or move in tandem because of spatial arbitrage. In the event of the emergence of a disparity between the domestic and foreign prices, international commodity arbitrageurs would, given the opportunity, actively seek profits by buying the good in the lower priced market and transferring it to the higher priced market. But should these traders be prevented from doing so due to the lack of price transparency, the existence of trade barriers, and/or the exercise of monopoly power, then the LOP would not hold and perfect market integration would not

take place. The competitive price relationship is summarized by the absolute (or strong) version of the LOP:

$$P^{\mathrm{A}} = P^{\mathrm{B}} \tag{1}$$

where P^{A} and P^{B} are local prices in area markets A and B.

In the real world, it is important to allow for transaction costs. For this reason, Stigler (1966) defines a market to be a spatial area within which the price of a good tends toward uniformity, with an allowance being made for transaction costs. In other words, areas A and B are considered to be a unified market if the following relationship holds:

$$P^{\mathrm{A}} = T + P^{\mathrm{B}} \tag{2}$$

where T accounts for sources of friction such as transportation and other transaction costs.

In the context of a domestic-foreign area market, the absolute LOP states that an identical good sells for the same common-currency price in both countries. In other words,

$$P = E \times P^{*} \tag{3}$$

where P is the home-country currency price, P^{*} is the partner-country currency price, and E is the exchange rate—defined as the home-currency price of one unit of the partner currency.

Applied researchers often base their statistical models of market integration upon the relative (or weak) version of the LOP. The LOP notion of market integration accommodates short-run price differences but requires that price changes across area markets correspond with each other on a one-to-one basis in the long run. An econometric representation of the "streamlined" LOP model, based on Eq. (2), can be expressed as follows:

$$p_t^h = \beta_0 + \beta_1 p_t^f + \varepsilon_t \tag{4}$$

where lowercase letters denote variables expressed in logs and p^h and p^f refer, respectively, to prices in the home and foreign-area markets expressed in common-currency terms and ε is the error term. The logarithmic specification of Eq.(4) reflects relative LOP in which transaction costs, embodied in the β_0 intercept, are assumed to vary in proportion to prices. This LOP notion of market integration accommodates short run price differences but requires that price changes across area markets correspond with each other on a one-to-one basis in the long run.

Eq. (4) assumes that transportation and other transaction costs vary proportionally to spatial prices. But, should actual costs be stochastic and/or nonstationary, this equation may generate biased parameter estimates. Moreover, ignoring differential transportation costs could induce nonlinearities (McNew and Fackler 1997). Inadequate treatment of transaction costs is likely to become more severe as transport rates increase in proportion to the value of the delivered good and as they become more volatile.

Unfortunately, transaction cost data are not readily available. Accounting for the many types of costs (i.e., transportation, handling fees, licenses, etc.) is difficult, especially

for lengthy periods that characterize our price series. Moreover, we do not believe that our primitive treatment of transaction costs unduly compromises the integrity of the empirical LOP estimates. Relatively short distances and reasonably open markets between the United States and Canada suggest that transaction costs are relatively minor determinants of prices. Barrett (1999) found that median transfer costs for agricultural commodities among the three NAFTA countries were small, less than 5% of source country domestic prices.

In the international context, it is often desirable to isolate the effect of exchange rates and to use own-currency prices (Goldberg and Knetter 1997).[5] Such a decomposition enables analysts to ascertain the extent to which exchange-rate-pass-through transmission and domestic, own-currency prices move, or do not move, together.

An econometric representation of the "detailed" LOP model, derived from Eq. (3), can be expressed as follows:

$$p_t = \beta_0 + \beta_1 p_t^* + \beta_2 e_t + \varepsilon_t \tag{5}$$

Viewing Eq. (5) as an export pricing equation for the home country, an appreciation of the home-country currency, which translates into a lower e_t, reduces foreign sales, unless the exporter is willing to lower its price to the importer.[6] Alternatively, viewing Eq. (5) as an import pricing equation for the home country, a depreciation of the home-country currency (a higher e_t), makes imports more expensive, permitting local producers to raise their prices. We, therefore, hypothesize a positive sign for the exchange-rate parameter.

We augment both the streamlined and the detailed-LOP models to control for dynamic factors such as cycles and seasonality and to account for government policies. The detailed model is expanded as follows:

$$\begin{aligned} p_t = {} & \beta_0 + \beta_1 p_t^* + \beta_2 e_t + \beta_3 A_t + \beta_4 A_t p_t^* + \beta_5 A_t e_t \\ & + \beta_{6i}(\text{specific commodity policy } i) + n_t \end{aligned} \tag{6}$$

The log specification means that β_1 and $(\beta_1 + \beta_4)$ are own-currency price transmission elasticities pre- and post-CUSTA/NAFTA, respectively. The dummy variable, A_t, takes a value of 0 before CUSTA/NAFTA started in 1989 and a value of 1 thereafter.[7] Commodity-specific policies include CVDs and the lifting of sanitary restrictions (LSR). The term, n_t, denotes the modeled autoregressive-moving-average error process which accounts for seasonality and cycles.

Eq. (6) can be used to ascertain several economic relationships. During the pre-CUSTA/NAFTA period, perfect (zero) transmission of locally denominated prices from the foreign to the domestic market occurs if $\beta_1 = 1(0)$, complete (zero) exchange-rate-pass-through transmission implies that $\beta_2 = 1(0)$, and perfect market integration (complete market segmentation) takes place when $\beta_1 = \beta_2 = 1(0)$. During the post-CUSTA/NAFTA period, perfect (zero) transmission of locally denominated prices from the foreign to the domestic market occurs if $(\beta_1 + \beta_4) = 1(0)$; complete (zero) exchange-rate-pass-through transmission implies that $(\beta_2 + \beta_5) = 1(0)$; and perfect market integration (complete market segmentation) takes place when $(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1(0)$.

Introducing Adjustment Lags

To extend and deepen the analysis of market integration to include the time dimension, we examine McNew (1996) and McNew and Fackler's (1997) notion of "market connectedness," using multivariate vector autoregression (VAR) models. The VAR perspective of market integration focuses on the price adjustment process, information not provided by the LOP model because the latter focuses on contemporaneous price relationships.[8] The VAR framework not only allows for lags in adjustment, but it accounts for feedback among the two nation's commodity prices. The feedback feature in VAR modeling prevents simultaneity bias of parameter estimates.

The standard form of the two-equation VAR model used to examine market connectedness is:[9]

$$P_{i,t} = \sum_{j=1}^{m} \phi_{ij1} P_{1,t-j} + \sum_{j=1}^{m} \phi_{ij2} P_{2,t-j} + \sum_{j=1}^{12} \phi_{ij4} \mathrm{SD}_j + \phi_{i15} A_t + \phi_{i1x}(G) + \varepsilon_{i,t} \qquad (7)$$

where $i = 1, 2$. Following Makridakis (1998), we use three subscripts for each right-hand-side coefficient: the first refers to the equation in the system, the second gives either lag-length or season, and the third indexes the endogenous variables. P_1 is the (U.S. dollar) home-country price, P_2 is the (U.S. dollar) partner-country price, SD_j are monthly seasonal dummies, A is the CUSTA/NAFTA dummy, and G represent other government policies potentially affecting prices in the various meat and livestock commodity markets such as the LSR and CVDs.

Akaike and Schwartz-Bayesian information criteria were used to choose m, the number of lags included for each endogenous variable. We also inspected the correlogram of residuals and employed lag exclusion Wald tests to ensure that m was of sufficient length that model estimations generated white noise residuals. We chose the Pesaran and Shin's (1998) "generalized" impulse-response method because, unlike the Cholesky method, it does not impose a causality ordering on the variables in the VAR.

We used conventional innovation-accounting procedures, including tests of Granger causality, impulse response functions, and impact multipliers to generate insights about the nature of adjustment dynamics characterizing the relationships between Canadian and U.S. meat and livestock markets. For example, impulse responses describe both how quickly and to what extent one country's price responds to a shock in another country. Larger and faster transmissions of price shocks imply more integration, with perfect market integration implying full and immediate transmission.

EMPIRICAL RESULTS

Findings About Stationarity/Nonstationarity

We pretested each of our data series for stationarity using Phillips–Perron (PP), Dickey–Fuller (ADF), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) statistics.[10] In the case of whole chickens, unit-root tests established the absence of a long-run equilibrium relationship between the U.S. and Canadian national markets. More specifically, they showed that the Canadian price series for whole chicken, unlike the U.S. series, follows a random walk. The two national markets can, therefore, be considered segmented.

All other commodity/product own-currency prices were deemed to be stationary. PP test statistics rejected the null hypothesis of nonstationarity for other commodity/

product own-currency price series, except Nebraska slaughter steers. However, both the ADF and the KPSS test statistics indicated that the prices series for Nebraska steers are stationary at the 5% level of significance.

By contrast, the null hypothesis of a unit root for the Canadian–U.S. exchange rate could not be rejected at the 10% level for neither the 1976:01–2001:12 (which corresponds with the availability of the national price series for slaughter steers), nor the 1979:01–2000:12 (which corresponds with the availability of the national price series for hogs). This means that it is not possible to obtain meaningful results from estimation of the detailed-LOP model (Eq. (6)) for hogs and steers.

However, PP unit-root test results for the weekly pork- and beef-product prices provided us with justification to estimate the detailed-LOP model for ham, spare ribs, beef loin, and chuck. We reject the null hypothesis of a unit root for own-currency product prices at either the 0.01 or the 0.05 level; and we reject nonstationarity for the Canadian–U.S. exchange rate at the 10% level in the 1988–2000 period.

Interestingly, monthly price series for all meat and livestock products, with the exception of whole chicken, were found to be stationary when converted to U.S. dollars. It was, therefore, possible to estimate the streamlined LOP model (derived from Eq. (4)) for hogs, hams, spare ribs, slaughter steers, chuck, and beef loin using U.S. and Canadian prices expressed in U.S. dollar terms.

Insights from the Detailed-LOP Model

The detailed-LOP model (Eq. (6)) generates information about the nature of cross-border integration as well as about the extent of foreign-price and exchange-rate transmission.[11] Tables 1 and 2 summarize the empirical results for the various pork- and beef-product markets using weekly data series.

Formal testing of market integration/segmentation of ham, spare ribs, beef loin, and chuck suggest that most Canadian–U.S. meat products are neither perfectly integrated nor completely segmented. Hypotheses that the U.S. and Canadian national markets are perfectly integrated ($\beta_1 = \beta_2 = 1$; $(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1$) were universally rejected at the 0.01 level. Moreover, hypotheses of complete U.S. and Canadian market segmentation ($\beta_1 = \beta_2 = 0$; $(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 0$) were rejected for all pork and for four of the eight beef-product markets. The exceptions allow for the possibility that market segmentation characterize some U.S.–Canadian beef markets.

On the basis of Fackler and Goodwin's observation that market integration often refers to a measure of degree rather than necessarily to strict adherence to the LOP, we conclude from the above joint F-tests that ham and spare ribs are partially integrated. We also conclude that pre-CUSTA/NAFTA Canadian chuck and post-CUSTA/NAFTA U.S. chuck, U.S. beef loin, and Canadian beef loin exhibit integration to some imperfect degree throughout the period of our analyses.

In addition to information about market integration/segmentation, the detailed-LOP models enabled us to determine the extent of (own-currency) foreign-price and exchange-rate transmission for ham, spare ribs, beef loin, and chuck. Some of the more interesting findings are summarized below:

Partial foreign price transmission occurs in most Canadian–U.S. meat markets. Witness the following two statistical test results: Hypotheses of complete foreign price transmission (($\beta_1 = 1$); $(\beta_1 + \beta_4) = 1$) are soundly rejected at either the 0.01 or the 0.05 level in all the pork and beef markets. Hypotheses of zero foreign price transmission (($\beta_1 =$

0); $(\beta_1 + \beta_4) = 0$) are rejected for all pork-product and four of the eight beef-product markets. The absence of foreign price transmission was not rejected for Canadian chuck post-CUSTA/NAFTA nor for U.S. chuck and both U.S. and Canadian beef loin during the post-CUSTA/NAFTA period.

The weekly transmission of (own-currency) foreign prices are considerably higher for pork than for beef. The average foreign price elasticity for U.S. and Canadian ham and spare ribs pre- and post-CUSTA/NAFTA was 0.47 (Table 1) while that for chuck and beef loin was 0.17 (Table 2). Individual product elasticities ranged from 0.03 to 0.43 for beef and from 0.32 to 0.65 for pork.

We were unable to reject the notion that partner prices affect (own-currency) domestic prices in the same way and to the same degree as exchange rates in most pork- and beef-product markets.[12] The hypothesis that parameter estimates for foreign prices and exchange rates are equivalent was rejected in only 3 of the 16 cases examined, namely, for the Canadian ham pre- and post-CUSTA/NAFTA and for U.S. beef loin post-CUSTA/NAFTA. The findings for the other 13 cases are consistent with what Richardson (1978) found when he performed formal statistical tests on how U.S. prices and exchange rates affected Canadian prices.

The evidence for complete transmission of exchange rates, as is the case for own-currency foreign prices, is not strong. The null hypothesis of complete exchange-rate transmission is rejected most everywhere—via *t*-tests pre-CUSTA/NAFTA (i.e., $\beta_2 = 1$) and via *F*-tests post-CUSTA/NAFTA (i.e., $\beta_2 + \beta_5 = 1$). Complete exchange-rate transmission could not, however, be rejected for U.S. ham exports to Canada post-CUSTA/NAFTA, witness the 1.10 *F* statistic. (Interestingly, the hypothesis of zero exchange-rate elasticity could not be rejected for Canadian ham exports to the United States.) Intermediate levels of exchange-rate pass-through characterize the market for spare ribs, with the weekly point elasticities ranging from 0.37 to 0.57.

Domestic U.S. and Canadian beef-product prices, in contrast to most domestic pork-product prices, are not generally responsive to contemporaneous fluctuations in Canadian–U.S. exchange rates post-CUSTA/NAFTA. The null hypothesis of zero exchange-rate transmission could not be rejected for beef-product flows, except for U.S. beef loin post-CUSTA/NAFTA.[13] These results demonstrate that changes in the exchange rate inhibit cross-border integration of Canadian and U.S. beef-product markets. A finding of zero exchange-rate pass-through indicates that a shift in the Canadian–U.S. exchange rate induces (common-currency) product prices in the two national markets to diverge.

The absence or near absence of contemporaneous exchange-rate transmission could conceivably be due to market inefficiency and/or a lack of information. While exporting firms may be very sensitive to own-currency commodity prices in domestic and foreign partner markets, they may be less sensitive (and possibly even largely unaware) of movements in the exchange rate. The exchange rate, being an economy-wide price ratio that reflects the value of national currencies, may be so far removed from specific commodity markets that it has little impact on the behavior of producers, at least in the short run, but potentially a large impact on their profit/loss situations. Should this be the case, cross-border trade among countries not having a common monetary unit of account would be more vulnerable to market segmentation than trade occurring among countries having the same currency.

Table 1. The detailed law-of-one-price model for ham and spare ribs (detailed-LOP model using weekly prices)

Exporting country own-currency domestic price	H_0	Cad ham	Cad spare ribs	U.S. ham	U.S. spare ribs
Intercept	β_0	0.60***	0.45***	−0.71***	−0.12
		(3.62)	(4.44)	(−3.41)	(−0.92)
Partner own-currency domestic price	β_1	0.46***, 0.46***	0.49***, 0.49***	0.55***, 0.55**	0.47***, 0.47***
		(3.59)[a], (4.20)[b]	(3.32)[a], (3.47)[b]	(2.85)[a], (2.31)[b]	(2.76)[a], (3.14)[b]
Exchange rate	β_2	−1.03, −1.03**	−0.25, −0.25**	−0.92, −0.92*	−0.07, −0.07*
		(−1.30)[a], (−2.58)[b]	(−0.47)[a], (−2.35)[b]	(−0.86)[a], (−1.80)[b]	(−0.12)[a], (1.86)[b]
CUSTA	β_3	−0.29*	−0.13	0.31	0.10
		(−1.76)	(−1.26)	(1.48)	(0.78)
CUSTA times partner price	β_4	−0.11	−0.17	0.02	−0.04
		(−0.87)	(−1.11)	(0.48)	(−0.23)
CUSTA times exchange rate	β_5	1.13	0.72	1.68	0.44
		(1.42)	(1.29)	(1.54)	(0.75)
Countervailing duties	β_6	−0.01***	−0.00	0.01**	0.00
		(−3.39)	(−1.31)	(2.01)	(0.51)
Lifting of sanitary regulations	β_7	0.02	0.01	−0.13***	0.00
		−0.6	0.46	(−3.04)	(0.17)
Goodness of fit	Adj R^2	88	96	94	95
Post-CUSTA		0.35	0.32	0.65	0.43
Price transmission elasticities	$\beta_1 + \beta_4 = 0$	[202.15]***	[106.40]***	[166.42]***	[112.84]***
	$\beta_1 + \beta_4 = 1$	[714.73]***	[474.48]***	[49.68]***	[201.99]***
Post-CUSTA		0.10	0.57	0.76	0.37
ERPT elasticities	$\beta_2 + \beta_5 = 0$	[0.59]	[8.89]***	[10.55]***	[6.42]**
	$\beta_2 + \beta_5 = 1$	[43.92]***	[11.54]***	[1.10]	[18.02]***
Pre-CUSTA					
Foreign-price = exchange-rate	$\beta_1 = \beta_2$	[3.36]*	[1.73]	[1.76]	[0.79]
Post-CUSTA					
Foreign-price = exchange-rate	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5)$	[3.39]*	[0.85]	[0.21]	[0.13]
Pre-CUSTA					
H_0: complete market segmentation	$\beta_1 = \beta_2 = 0$	[6.83]***	[5.52]***	[4.20]**	[3.81]**
H_0: perfect market integration	$\beta_1 = \beta_2 = 1$	[13.55]***	[9.38]***	[4.89]***	[6.93]***
Post-CUSTA					
H_0: complete market segmentation	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 0$	[103.77]***	[56.42]***	[88.16]***	[57.08]***
H_0: perfect market integration	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1$	[357.80]***	[240.25]***	[25.03]***	[103.87]***

Note: Parentheses denote *t* statistics; brackets denote *F* statistics.
*Denotes the null hypothesis is rejected at the 0.10 significance level, ** at the 0.5 level, and ***at the 0.01 level.
[a] *t*-Test with the null mean equal to zero.
[b] *t*-Test with the null mean equal to one.

Table 2. The detailed law-of-one-price model for chuck and loin (detailed-LOP model using weekly prices)

Exporting country own-currency domestic price	H_0	Cad chuck	Cad loin	U.S. chuck	U.S. loin
Intercept	β_0	0.24***	1.24	−0.16	0.87***
		(−2.96)	(5.81)	(−1.27)	(4.80)
Partner own-currency domestic price	β_1	0.43***, 0.43***	0.18, 0.18***	0.18, 0.18***	0.10, 0.10***
		(3.74)[a], (−4.9)[b]	(1.02)[a], (−4.80)[b]	(1.61)[a], (−7.58)[b]	(0.76)[a], (−7.09)[b]
Exchange rate	β_2	0.25, 0.25*	−0.43, −0.43*	−0.36, −0.36***	0.02, 0.02
		(0.59)[a], (−1.79)[b]	(−0.53)[a], (−1.78)[b]	(−0.56)[a], (−2.11)[b]	(0.03)[a], (−1.58)[b]
CUSTA	β_3	0.11	−0.20	0.06	−0.05
		(1.32)	(−0.95)	(0.43)	(−0.31)
CUSTA times partner price	β_4	−0.40	0.01	0.05	−0.02
		(−3.41)	(−0.08)	(−0.40)	(−0.17)
CUSTA times exchange rate	β_5	−0.11	0.78	0.61	−0.37
		(−0.26]	(−0.92)	(0.89)	(−0.58)
Goodness of fit	Adj R^2	95	96	92	92
Post-CUSTA		0.03	0.16	0.23	0.08
Price transmission elasticities	$\beta_1 + \beta_4 = 0$	[1.41]	[6.46]***	[11.75]***	[3.68]**
	$\beta_1 + \beta_4 = 1$	[1535.65]***	[782.70]***	[137.31]***	[2259.56]***
Post-CUSTA		0.13	0.36	0.25	−0.35
ERPT elasticities	$\beta_2 + \beta_5 = 0$	[1.16]	[1.64]	[1.45]	[5.13]**
	$\beta_2 + \beta_5 = 1$	[48.73]***	[5.24]**	[13.12]***	[77.83]***
Pre-CUSTA					
Foreign-price = exchange-rate	$\beta_1 = \beta_2$	[0.18]	[0.51]	[0.67]	[0.01]
Post-CUSTA					
Foreign-price = exchange-rate	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5)$	[0.70]	[0.47]	[0.01]	[7.79]*
Pre-CUSTA					
H_0: complete market segmentation	$\beta_1 = \beta_2 = 0$	[7.12]***	[0.60]	[1.47]	[0.29]
H_0: perfect market integration	$\beta_1 = \beta_2 = 1$	[13.51]***	[14.53]***	[30.67]***	[26.50]***
Post-CUSTA					
H_0: complete market segmentation	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 0$	[1.21]	[7.09]***	[6.25]***	[7.12]***
H_0: perfect market integration	$(\beta_1 + \beta_4) = (\beta_{2+} \beta_5) = 1$	[777.41]***	[166.55]***	[71.68]***	[526.55]***

Note: Parentheses denote t statistics; brackets denote F statistics.

*Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.5 level, and ***at the 0.01 level.

[a] t-Test with the null mean equal to zero.

[b] t-Test with the null mean equal to one.

The absence of substantial exchange-rate pass-through could also be due to strategic market behavior and price discrimination. Nationally based firms may trim prices when shipping merchandise to a trading partner whose currency has lost value in order not to lose export sales and/or to maintain their shares in the partner market. Conversely, exporters to partner markets whose currency has appreciated may allow prices to fall (in foreign-currency terms) in the importing market, while keeping prices fixed (in national-currency terms) in the domestic market if such a strategy would augment profit margins overall.

Another possible explanation for little or no empirical evidence of exchange-rate pass-through found in this analysis of commodity agriculture is that the LOP framework could be limiting because of its restricted focus on contemporaneous relationships. The full impact on commodity prices of an autonomous shift in the exchange rate does not always occur instantaneously. Price adjustments may take time more than a week (the observational frequencies of the data series used in this LOP analysis) to play themselves out completely. The development of dynamic models capable of examining the time dimension related to such adjustments offers a promising avenue for future research. In an effort to examine the dynamics of price adjustments more thoroughly, we use the VAR analytical framework to empirically evaluate market connectedness in a later section of this paper.[14]

Information Generated from the Streamlined-LOP Model

Let us now turn attention to analyses based upon the streamlined-LOP model, derived from Eq. (4). This framework enables us to draw comparisons about the degree of integration characterizing all meat and livestock commodity flows, except whole chicken (see, Table 3).

The Extent of Integration in Livestock Markets

The econometric results for live animals clearly show that U.S. and Canadian hog and slaughter steer markets are not nationally distinct.[15] The null hypothesis of complete market segmentation was universally rejected for all livestock product flows, see the *F*-tests in Table 4. Point elasticity estimates show that the Canadian–U.S. hog market is more integrated than the joint national market for steers. The average pre- and post-CUSTA/NAFTA partner price transmission elasticity for hogs was 0.81, while that for slaughter steers was 0.70. Point estimates show that the degree of market integration for hogs intensified post-CUSTA/NAFTA, rising from 0.72 to 0.90, but fell from 0.74 to 0.66 for steers.

We found, as Fackler and Goodwin have suggested might be the case, that the degree of integration in any given commodity/product market is not symmetrical from all market participants' points of view. From the perspective of either the typical Canadian exporter or U.S. importer, for example, the joint national hog market is more integrated than from the standpoint of the average U.S. exporter or Canadian importer.

The free trade agreement increased the degree of integration in the continental hog market—with the post-CUSTA/NAFTA, Canadian slaughter price elasticity with respect to the U.S. slaughter price increasing 0.20 percentage points higher than pre-agreement to 0.94, and the U.S. slaughter price elasticity with respect to the Canadian slaughter prices rising 0.17 percentage points to 0.86 between the two periods.[16] Moreover, Chow tests

Table 3. Degree of bilateral market integration (streamlined-LOP model)

	Monthly price elasticities		CUSTA	LSR
	Pre-CUSTA	Post-CUSTA	Chow test[a]	*F* test[b]
U.S. ham to Canada[c]	0.69**	0.99***	0.617	14.31***
	(2.02)	(14.01)		
Cad ham to United States[c]	0.68*	0.52***	1.217	1.225
	(1.66)	(13.32)		
U.S. spare ribs to Canada[c]	0.34	0.55***	0.388	0.695
	(1.09)	(9.50)		
Cad spare ribs to United States[c]	0.75***	0.58***	0.309	0.271
	(3.27)	(9.16)		
U.S. beef loin to Canada	0.54***	0.41***	0.361	
	(3.05)	(7.39)		
Cad beef loin to United States	0.10	0.25***	0.536	
	(0.38)	(3.16)		
U.S. chuck to Canada	0.06	0.49***	1.072	
	(0.16)	(5.06)		
Cad chuck to United States	0.53*	0.16***	4.25***	
	(1.67)	(2.95)		
U.S. hogs to Canada[c]	0.69***	0.86***	3.75***	0.646
	(11.77)	(22.11)		
Cad hogs to United States[c]	0.74***	0.94***	4.84***	4.818**
	(13.39)	(24.09)		
U.S. steers to Canada	0.98***	0.75***	24.87***	
	(29.25)	(17.31)		
Cad steers to United States	0.50***	0.56***	1.360	
	(10.99)	(8.18)		

Note: Parentheses denote *t*-statistics.

*Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level.

[a]Tests the joint significance of the CUSTA variable and the interaction term.

[b]Tests the significance of the lifting of sanitary restrictions (LSR).

[c]The model controlled for both (1) U.S. countervailing duties imposed on Canadian hogs between April 1985 and March 1997 and (2) the removal of Canadian sanitary restrictions in December 1998.

could not reject the hypothesis of perfect market integration in the post-CUSTA/NAFTA period for Canadian hog exports to the United States. The joint *F*-tests suggest, by contrast, that the hog market for U.S. exporters and Canadian importers is partially integrated, in both the pre- and post-agreement periods.

F-tests show that the Canadian–U.S. market for slaughter steers was perfectly integrated pre-CUSTA/NAFTA, but not afterward. The U. S. slaughter price elasticity with respect to the Canadian slaughter price fell 0.23 percentage points to 0.75 post-CUSTA/NAFTA. Chow tests of structural change pre- and post-agreement suggest that decreased integration occurred in the U.S.-to-Canadian slaughter steer case, in marked contrast to increased market integration for continental hogs (Table 3). The Chow test of

Table 4. Null hypotheses: complete market segmentation and perfect market integration (streamlined-LOP model)

	Complete market segmentation		Perfect market integration	
	Pre-CUSTA	Post-CUSTA	Pre-CUSTA	Post-CUSTA
			F statistics	
U.S. exporter/Canadian importer perspective				
Ham	4.08*	196.17***	**0.86**	**0.04**
Spare ribs	**1.20**	90.20**	4.60**	59.97***
Beef loin	9.32***	54.62***	6.89***	113.95***
Chuck	**0.02**	25.64***	6.40**	28.74***
Hogs	138.45***	488.44***	28.33***	11.46***
Steers	855.48***	299.52***	**0.32**	32.38***
Canadian exporter/U.S. importer perspective				
Ham	2.75*	177.55***	**0.59**	148.34***
Spare ribs	10.69**	83.85***	**1.21**	44.98***
Beef loin	**0.14**	10.02***	11.98***	92.49***
Chuck	2.82*	8.73***	**2.15**	252.90***
Hogs	179.17***	580.41***	21.14***	**2.46**
Steers	120.85***	66.86***	122.91***	42.23***

Note: Numbers in boldface denote inability to reject the null hypothesis.
*Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level.

no structural change could not be rejected in the Canadian-to-U.S. steer case where the estimated level of integration rose from 0.50 to 0.56 post-CUSTA/NAFTA.[17]

The Extent of Integration in Meat-Product Markets

The streamlined-LOP model results provide empirical evidence, consistent with findings from the detailed model, that (1) "intermediate" levels of integration characterize the union of most Canadian–U.S. red-meat markets and (2) the pork-product markets in North America are more integrated than the beef-product markets. The average monthly partner price elasticity for ham and spare ribs post-CUSTA/NAFTA was 0.66 (Table 3). By contrast, the corresponding average elasticity for beef loin and chuck was 0.33.

In most cases, the null hypotheses of complete U.S. and Canadian market segmentation and perfect Canadian–U.S. market integration for pork and beef products were rejected using joint *F*-tests. The implication is that the two national markets for red meat are, in most instances, partially integrated. A notable exception is the U.S.-to-Canadian market for ham. U.S. exporters and Canadian importers view this market as being perfectly integrated. With monthly elasticity point estimates of 0.69 pre-CUSTA/NAFTA and 0.99 post-CUSTA/NAFTA in the U.S. equation, the null hypothesis that the relative LOP is operative could not be rejected in either the pre- or post-CUSTA/NAFTA period.

Other exceptions to partial integration include Canadian exports of beef loin to the United States and U.S. exports of spare ribs and chuck to Canada in the pre-CUSTA/NAFTA period where parameter estimates for the foreign price were found

not to be statistically different than zero. Chow tests do not provide any statistical evidence of structural change pre- versus post-CUSTA/NAFTA for any meat product, except Canadian-to-U.S. chuck.

VAR Model Results

VAR models enable us to introduce dynamics into our empirical analyses of market integration. The VAR framework provides a perspective of market integration that focuses on the price-adjustment process and that generates information about the speed and relative magnitude of foreign-price shocks affecting domestic prices. Unlike LOP models, VAR models allow for feedback effects among all endogenous variables. Moreover, VAR models are not constrained by issues of data stationarity.[18] The use of VAR, therefore, enabled us to extend our analysis of integration of the whole-chicken market beyond that which was implied from the unit-root tests. We begin by looking at this sector.

Whole Chicken

Plots of impulse responses for whole chicken show that while bird prices in both the U.S. and the Canadian national markets are responsive to commodity home-price shocks, they are insulated from shocks emanating from each other's markets. A one-standard-deviation innovation in the Canadian whole-chicken price does not illicit a response in the U.S. market that is statistically different from zero. A home-country shock in Canada, by contrast, takes $2\frac{1}{2}$ years to dissipate in its domestic market. Similarly, a one-standard-deviation innovation in the U.S. whole-chicken price takes almost 2 years to cease affecting prices in the U.S. market. The U.S. innovation has a very minor (i.e., almost zero) effect on Canadian whole-chicken prices for 3–10 months before dying out completely.

Block-exogeneity-Wald tests provide additional evidence of an absence of cross-border connectivity in whole chicken (Table 5). Prices in neither country are shown to Granger-cause prices in the other's national market.

The findings from the VAR analysis for whole chicken are consistent with the unit-root tests conducted earlier. Both point to segmentation of the Canadian and U.S. markets.

Table 5. Granger causality tests

	Chi-square statistics	
	$p^{us} \rightarrow p^{ca}$	$p^{ca} \rightarrow p^{us}$
Ham	4.55**	1.56
Spare ribs	9.36**	3.29*
Chuck	2.54	12.25**
Loin	14.31***	5.23**
Hogs	42.78***	0.30
Steers	24.85***	7.67**
Whole chicken	2.44	1.48

*Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level.

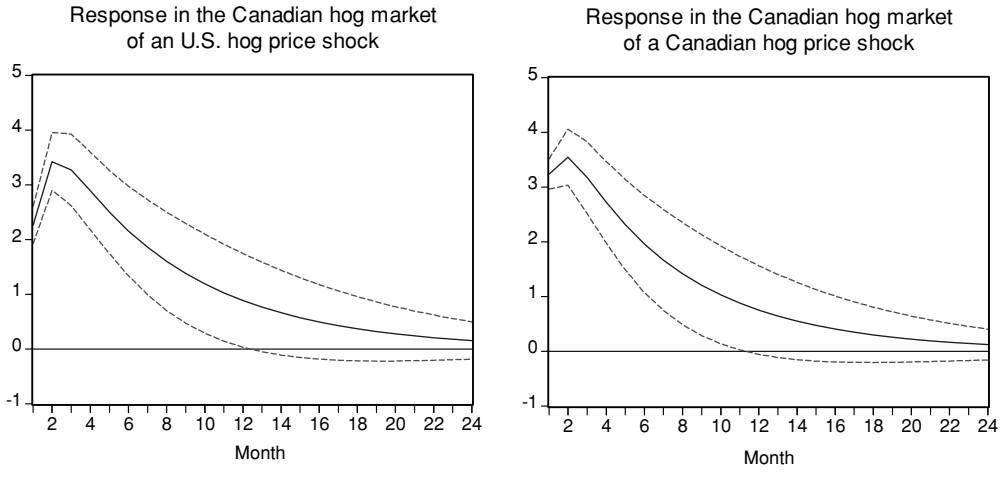

Figure 1. Price responsiveness in the Canadian hog market to a generalized one-standard-deviation innovation, plus or minus two standard errors

Livestock Markets

In hogs, the VAR analysis shows connectivity in the U.S.-to-Canadian, but not in the Canadian-to-U.S., hog market. Exogeneity tests reveal that prices for U.S. hog Granger-cause Canadian prices; but they do not support the hypothesis that Canadian hog prices impact U.S. prices. Impulse-response functions show the Canadian hog market to be highly integrated with that of the United States, Figure 1. The fallout from U.S. and Canadian price shocks in Canada are similar both in terms of patterns and magnitude. Initially, a domestic shock to hog prices in Canada has a 1.4 times greater impact in the Canadian market than does a corresponding U.S. shock. Thereafter, the influences are nearly identical with the 12-month U.S. multiplier of 24.4 almost equaling the 12-month Canadian multiplier (23.9). These findings provide empirical evidence supporting the contention that "Canadian hog prices are set in the United States (Haley 2004)." The asymmetric relationship in the national hog markets is likely due to the relatively large size of the U.S. market and rapid growth of Canadian hog exports to the United States.

Similar logic has been used to posit that cattle prices are determined in the U.S. rather than the Canadian market (Young and Marsh 1998). Block-exogeneity tests reveal, however, that two-way connectivity depicts the Canadian–U.S. steer market. Moreover, there is little difference in the way home- and partner-price shocks for slaughter steers affect the Canadian and U.S. national markets (Figure 2). In the Canadian (U.S.) market both Canadian and U.S. innovations take 11 (13) months to dissipate. Note also that in both Canadian and U.S. national markets, the initial as well as the 12-month multipliers are modestly greater for the home-country innovation than for the partner-country innovation. The finding that price shocks from either country affect each national steer markets in similar ways is an indicator of market integration. This said, the fact that home-country impacts were 17% greater than partner-country impacts in the U.S. steer market whereas they were 5% greater in the Canadian steer market, provides some evidence for greater integration in the Canadian-to-U.S. market than in the U.S.-to-Canadian market.

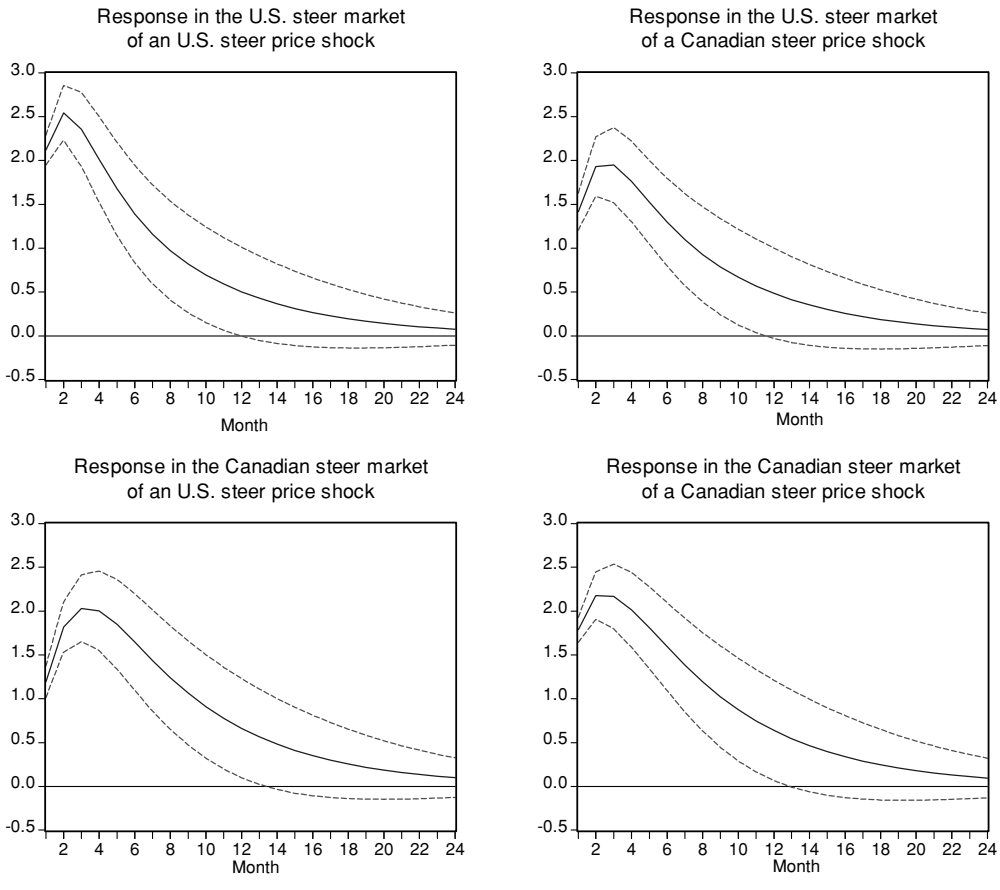

Figure 2. Price responsiveness in Canadian and U.S. slaughter steer markets to a generalized one-standard-deviation-innovation, plus or minus two standard errors

Meat-Product Markets

Chi-square tests of connectivity show two-way integration for spare ribs and beef loin, but one-way integration for ham and chuck. The direction of causality for ham goes from the United States to Canada, whereas the directional flow for chuck flows from Canada to the United States.

In the case of two-way integration for spare ribs, the home-country impulse-response patterns are similar for both U.S. and Canadian exporters as are the partner impulse-response patterns, see Figure 3. Both domestic and foreign price shocks impact national prices over approximately the same time period (i.e., 12 and 13 months). Moreover, home country-to-partner country (1-year) multipliers for both exporters are similar (ranging from 1.3 to 1.5). Comparatively uniform innovative-accounting statistics point to an integrated Canadian–U.S. market for spare ribs.

In the case of two-way integration for beef loin, a home-country innovation for the United States had twice the impact on domestic prices as does a Canadian innovation after

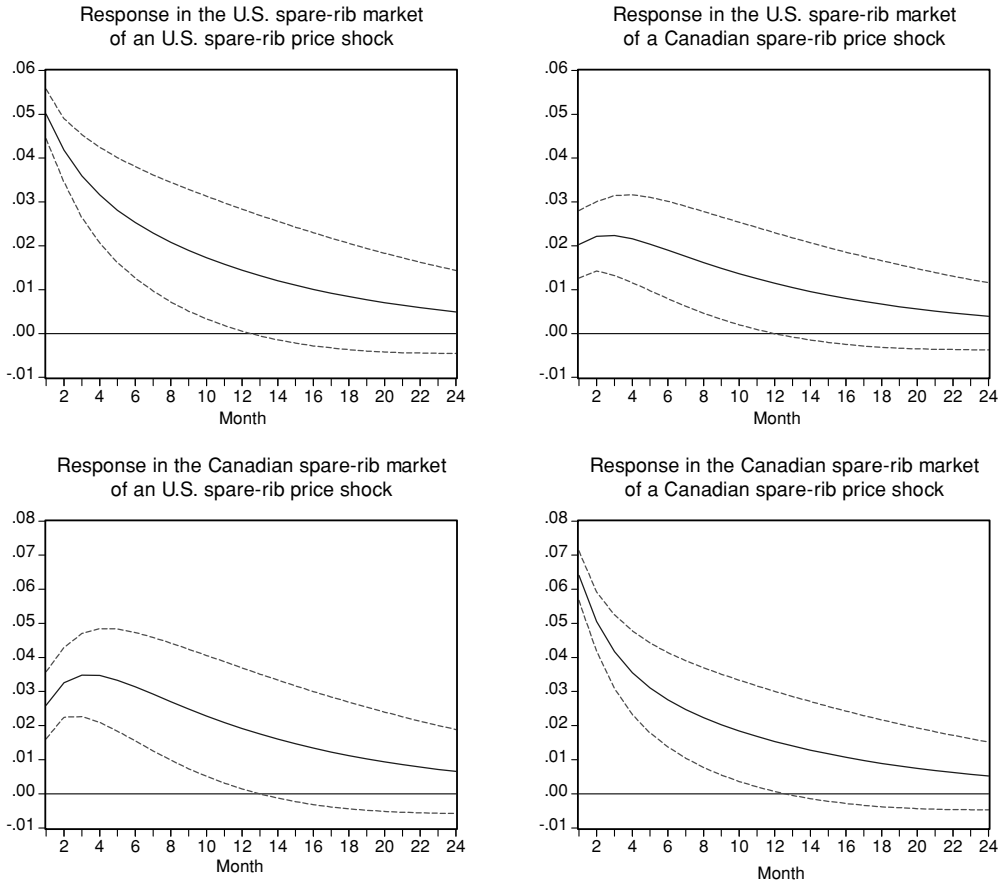

Figure 3. Price responsiveness in Canadian and U.S. spare-rib markets to a generalized one-standard-deviation-innovation, plus or minus two standard errors

10 months, the period of time over which impulse responses were statistically greater than zero. By contrast, a home-country innovation for Canada had a one-third greater impact than a U.S. innovation for the same time period. This finding suggests deeper integration in the Canadian-to-U.S. beef-loin market than in the corresponding U.S.-to-Canadian market.

In the case of Canadian-to-U.S. connectivity in chuck, a U.S. price shock has four times the impact on chuck prices in the United States as a corresponding Canadian price shock (Figure 4). The initial asymmetric response is not unusual, given the distances separating national markets and the time required for adjustments to occur. The accumulated impulse responses of U.S. and Canadian innovations were virtually identical by the 14th month, providing evidence of integration in the Canadian-to-U.S. market for chuck.

Deep integration portrays the U.S.-to-Canadian ham market but not the Canadian-to-U.S. market. The initial impact of a home-country innovation on the ham price in Canada is modestly greater than that of a U.S. price shock (Figure 5). Shortly thereafter,

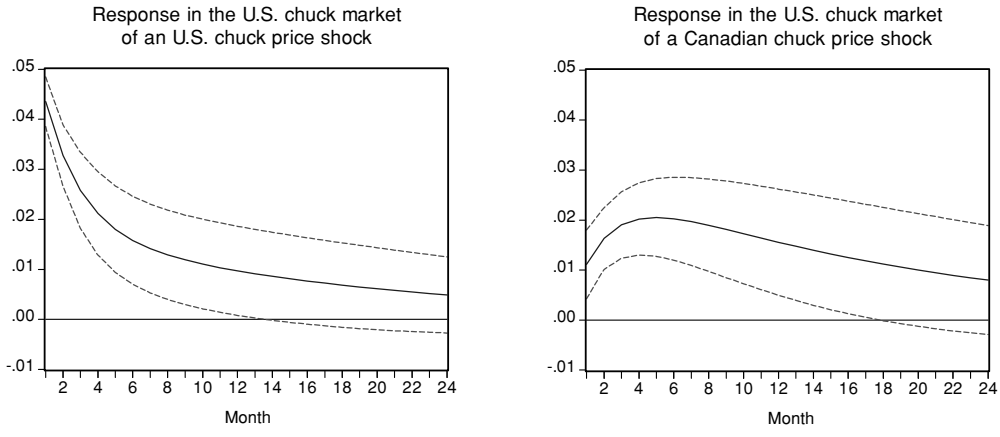

Figure 4. Price responsiveness in the U.S. chuck market to generalized one-standard-deviation innovation, plus or minus two standard errors

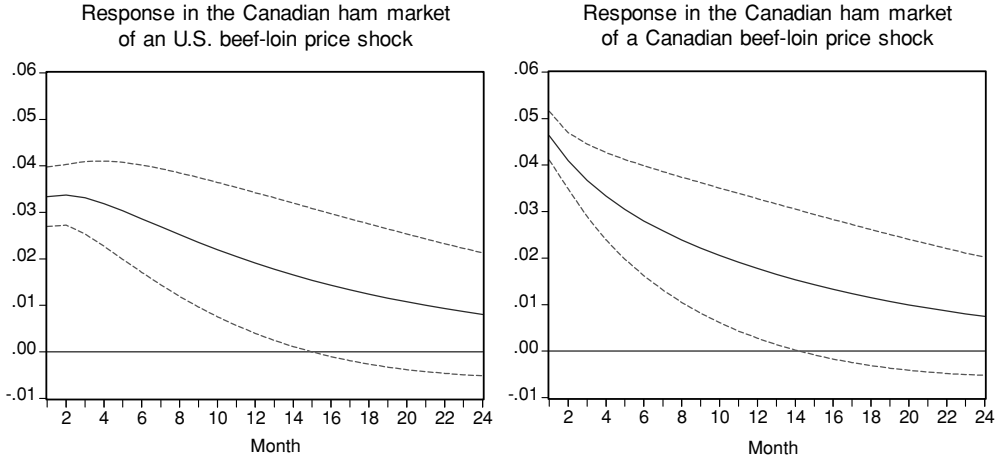

Figure 5. Price responsiveness in the Canadian ham market to a generalized one-standard-deviation innovation, plus or minus two standard errors

the impacts of U.S. and Canadian price shocks reach parity. In fact, after just 3 months, the influence of an U.S. price innovation becomes slightly larger. Note also that the accumulated impacts of home- and partner-price shocks on the domestic price of Canadian ham are almost identical, over the period when both are influential (i.e., 14 months). Collectively, these findings indicate that perturbations in the U.S. and Canadian markets bear almost equally upon the domestic prices for ham in Canada.

FINAL OBSERVATIONS

Expectations within the U.S. and Canadian meat and livestock sector were high at the outset of the CUSTA/NAFTA negotiations. There was widespread belief that the regional

accord between the United States and the Canada would lead to the removal of existing nontariff barriers either through policy harmonization, national treatment, or through the granting of equivalencies.

Some barriers were, in fact, eliminated post-CUSTA/NAFTA. Most notable were trade policy reforms in the hog market where sanitary restrictions were lifted and CVDs removed. Not surprisingly, the empirical evidence of deeper integration post-CUSTA/NAFTA was strongest for the continental hog market.

Despite the success story for hogs, the consensus among commodity analysts is that the advancement made in dismantling the nontariff barriers to trade in the meat and livestock sector has been disappointing. The econometric findings in this study support the contention that the progress achieved increasing unification of the sector was modest overall.

The beef market is an area of particular concern as beef products continue to exhibit low levels of partner price transmission elasticities. Country-of-origin labeling requirements and the absence of national grade equivalencies undoubtedly play major roles explaining the relatively large degree of market segmentation characterizing the beef-product markets. The labeling of imported beef is costly and likely contributes to national price differentials in the various U.S. and Canadian beef products. Moreover, Canadian beef cannot be sold in the United States as USDA-stamped choice, select, or standard beef, nor can U.S. beef be sold in Canadian retail outlets as A, AA, or AAA beef. Such institutionally based, nontariff barriers effectively tax products crossing the Canadian–U.S. border. They may explain why packaged-beef imported into U.S. and Canadian retail outlets is sold at a 3–5% discount.

Another significant barrier to cross-border integration is the exchange rate. The fact that the Canadian dollar experienced a secular decline in its value *vis-à-vis* the U.S. dollar combined with empirical findings of low exchange-rate pass-through transmission indicate that Canadian suppliers have experienced a profit advantage relative to U.S. suppliers in the recent past. This profit advantage varies with the relative strength of the respective currencies. The fall in the value of the U.S. dollar since October 2002 suggests that this advantage may be disappearing.

NOTES

[1]Witness the temporary imposition of countervailing duties (CVDs) on Canadian pork products in 1985 and again in 1989 as well as antidumping tariffs (ADs) on Canadian slaughter cattle in 1999. These CVDs and ADs were rescinded shortly after having been levied, following considerable deliberation among national policymakers (Benson et al 1994; Meilke and Sarker 1997; Brester et al 2003).

[2]U.S. wholesale steer, hog, and pork and beef product prices were obtained from the Agricultural Marketing Service (AMS) of USDA; while corresponding livestock and meat prices in Canada were obtained from Agriculture and Agri-Food Canada. Prices for Omaha-based beef and pork cuts and corresponding Montreal-based cuts were obtained on a weekly (January 3, 1988–December 31, 2000) and monthly (1988:01–2000:12) basis. Nebraska slaughter steer prices and prices for Toronto slaughter steers cover the 1976:01–20001:12 period. Central-based U.S. and Manitoba-based prices for dressed hog cover the 1979:01–2001:12 period. U.S. countervailing duties imposed on Canadian swine from April 3, 1985 through March 31, 1997 were obtained from the U.S. Federal Registry and the Import Administration within the Department of Commerce, see http://ia.ita.doc.gov/esel/eselframes.html. For Canadian whole chicken 18 years

of monthly provincial retail prices (1985:01–2002:05) were obtained from Agriculture Canada's electronic-information-service (ACEIS) web site: www.agr.ca/misb/aisd/poultry/poulsece.htm. A population-weighted price series was calculated and used to compare with weighted U.S. city-wide whole-chicken retail prices obtained from the U.S. Bureau of Labor Statistics: www.bls.gov. Canadian–U.S. exchange rates were obtained from the Pacific Exchange Rate Service: www.pacific.commerce.ubc.ca/xr/data.html.

[3]The *Farm Products Marketing Agencies Act* of 1972 established agencies responsible for controlling production and marketing on a national basis in the poultry industry. These agencies allocate national output among each of the provinces.

[4]The imposition of these tariffs falls outside the time period covered by the empirical analyses in this study.

[5]Many analysts ignore the impact of the changing value of exchange rates altogether by converting domestic prices into a common currency (Crouhy-Veyrac et al 1982; Carter and Hamilton 1989). Other analysts have circumvented the exchange-rate problem by using traded prices (i.e., U.S. dollar-denominated *fob* and *cif* prices) rather than domestic prices expressed in own-currency terms (Goodwin 1992).

[6]Complete exchange-rate pass-through assumes a one-for-one response between national prices and the exchange rate.

[7]We also examined empirical evidence supporting the phase-in of CUSTA/NAFTA using two procedures: (1) the CUSTA/NAFTA dummy was allowed to change gradually from zero to one between January 1989 and January 1993—the period over which tariffs were "accelerated to completion" and (2) random coefficient models were estimated in an attempt to identify possible trajectories in the foreign price coefficients through time. The phased-in CUSTA/NAFTA dummy did not alter the price coefficients to any appreciable degree. Moreover, there were no discernable shifts in the price coefficients spanning the implementation period using the random coefficients model. For these reasons, we only report model results that used the standard CUSTA/NAFTA dummy.

[8]We could have attempted to examine the speed of transmission question in the LOP model by including lags of the partner-country price as regressors. Enders (1995), however, points out that lagged prices are "likely to be highly collinear, implying that the *t*-tests on individual coefficients may not be reliable." This led us to avoid using lagged prices in the LOP model. Our LOP model specification enabled us to make statements about not only the scale, but also the statistical validity, of the effect of foreign prices and exchange rates on domestic prices.

[9]The VAR models for hogs, ham, and spare ribs include U.S. CVDs levied on Canadian swine and the LSR on U.S. hogs by Canada. The VAR models for slaughter steers, beef loin, and chuck include dummy variables for (1) the LSR on U.S. feeder cattle by Canada in the Fall of 1998 and (2) the 5-month ADs imposed by the United States on Canadian slaughter cattle beginning in July 1999. The model for steers also includes a trend dummy to account for the hyper-inflationary period between 1978:02 and 1979:04.

[10]Unit-root test results are available from the authors on request.

[11]All LOP equations for swine include U.S. CVDs imposed on Canadian hogs (U_CVD) and a dummy variable for the removal of sanitary restrictions imposed by Canada on U.S. swine (C_LSR).

[12]Failure to reject this null hypothesis could be due to the large variance of the differences in the two estimated elasticities.

[13]But note that the post-CUSTA/NAFTA point estimate for U.S. beef loin ERPT , −0.35, is of the wrong sign. However, when monthly rather than weekly data are used, the post-CUSTA/NAFTA beef loin exchange-rate elasticity (not shown here but available from the authors) does have the correct sign. But even here, there is little evidence of exchange-rate pass-through for U.S. beef loin, as the monthly point estimate of 0.02 is small and the corresponding tests of statistical significance suggest zero transmission.

[14]This section focuses on the relationships between Canadian and U.S. commodity prices, expressed in common-currency terms. To shed light about how commodity prices respond to changes in the exchange rate, we also estimated impulse response functions of a three-way VAR linking own-currency commodity prices in Canada and the United States with the exchange rate. U.S. and Canadian meat price shocks were found not to impact the bilateral exchange rate. This is hardly surprising given the small role agricultural commodity prices play in determining the value of the U.S. and Canadian dollars. Somewhat more surprising was the finding that exchange-rate shocks do not significantly affect own-currency prices for the various meat and livestock commodities in either country. The implication of this discovery is that the Canadian–U.S. exchange rate is a constraining factor inhibiting spatial integration in Canadian–U.S. markets because the exchange rate does not act as an efficient transmission mechanism connecting foreign and domestic prices. (Detailed results of the three-way VAR analyses, though not presented in this paper, are available from the authors on request.)

[15]The LSR imposed by Canada on U.S. swine (C_LSR) had a statistically significant negative effect on hog prices in Canada, but no apparent effect on hog prices in the United States. The lower prices for swine in Canada likely rendered Canadian processing more competitive, increasing pork exports to the United States. The statistically significant negative impact of the C_LSR on ham prices in the United States may have been due to increased competitiveness of Canadian ham attributable to lower prices of hogs in Canada. The latter induced, in part, by the LSR on U.S. hogs. Coefficients for U.S. CVDs (U_CVD) were negative in the Canadian equations for ham and spare ribs, indicating that these duties may have depressed prices for pork products in Canada. Note, however, that the U_CVD coefficients were not statistically significant.

[16]Empirical model results show that both CUSTA/NAFTA and the LSR imposed on U.S. hogs by Canada impacted hog prices in Canada at the 0.05 level significance. Analytical results from estimation of a random coefficient model (available from the authors on request) suggest that LSR had a more pronounced effect than CUSTA/NAFTA on Canadian–U.S. price convergence.

[17]A reviewer suggests that the Toronto slaughter steer price series may not be able to isolate or capture the CUSTA/NAFTA effect because of simultaneous structural change whereby the production and processing of slaughter fed cattle shifted to Western Canada coincided with the creation of the free trade agreement.

[18]Sims (1980) and others, such as Doan (1992), recommend against differences even if variables contain a unit root.

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